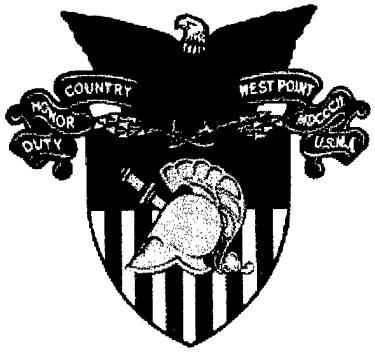
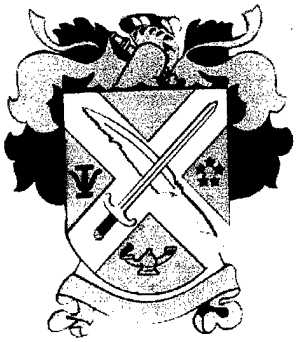
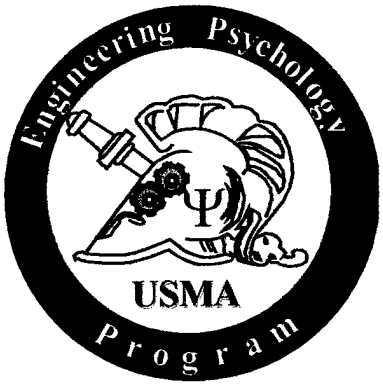




Human Factors Considerations for the Tags/Minimally Guided Munitions APL Alternative

Eugenia M. Kolasinski, Ph.D.



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In October 1997, the Department of Defense was directed to find alternatives to anti-personnel landmines (APLs) so that the US can end use of APLs by 2003 (2006 within Korea). As part of the APL alternative development process, the Defense Advanced Research Projects Agency (DARPA) is investigating innovative long-term alternatives to APLs. The Tags/Minimally Guided Munitions (Tags/MGM) concept is one DARPA-proposed APL alternative. The system involves guiding short-range indirect fire through the use of small transmitters attached to enemy soldiers. This paper discusses human factors issues involved in the development and implementation of the Tags/MGM concept. A model of tag effects on soldier behavior is proposed. Based on this model, four major human factors issues involved in the concept are identified and discussed: tag characteristics, enemy knowledge of the Tags/MGM system, behavior of tagged enemy soldiers, and behavior of untagged enemy soldiers. Potential design considerations, potential psychological and behavioral effects, and potential operational effects of the Tags/MGM system are discussed as applications and areas for future research.

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Table of Contents

Introduction

Fear thrives on frustration. It persists and grows when danger impends, especially if there is nothing the fearful man can do to lessen the threat against him.

- Boring, 1945, p. 383

On September 17, 1997, President Clinton announced that by the year 2003, the United States will no longer use anti-personnel landmines (APLs) outside of Korea and, within Korea, the goal is to have APL alternatives ready by 2006 (White House, 1997). In October 1997, the Deputy Secretary of Defense directed all elements of the Department of Defense (DOD) to implement the President's policy. This process involves two tracks: short-term replacement of APLs and long-term alternatives to their use. In October 1997, as part of the second track, the Deputy Secretary of Defense directed the Defense Advanced Research Projects Agency (DARPA) to investigate innovative long-term approaches to APL alternatives. To this end, DARPA's Track 2 program seeks to search for new ideas regarding both APL alternatives and new concepts that might eliminate the need for APLs in warfighting altogether. Two new concepts have been identified by DARPA for further investigation: a self-healing minefield and the Tags/Minimally Guided Munitions (Tags/MGM) concept.

Initially, this research project intended to investigate the many issues surrounding development and implementation of both of these concepts. The aim was to reveal relevant literature, web sites, researchers, companies, and concepts that could provide references, insight, or existing or proposed enabling technology to support the self-healing minefield, tags, and related APL alternatives. However, in order to focus the efforts of this work, it appeared more worthwhile to concentrate on the soldier behavior issues surrounding the development and implementation of the Tags/MGM concept only. Of special interest was identifying researchers who are currently or have successfully investigated soldier behavior and/or conducted systematic studies in the field. To this end, the goal was to provide recommendations for appropriate researchers to conduct future studies related to soldier responses to tags. Unfortunately, little directly relevant findings were uncovered in the existing literature. Thus, the overall mission became to provide human factors guidance regarding the development and implementation of the Tags/MGM concept.

A Brief Overview of Landmine Warfare

Although a thorough discussion of landmine warfare is not necessary here, the information below provides a cursory summary as a context for discussion of APL alternatives. The summary presented here has four major parts: the military utility of landmines, the psychological effects of landmines, the operational effectiveness of landmines, and implications for the development of APL alternatives.

Military Utility

As used in this report, the term "military utility" of APLs refers to the role that APLs play in military operations according to United States doctrine. As such, the primary source for ascertaining the military utility is U.S. doctrine: *Field Manual 20-32: Mine/Countermine Operations* (Department of the Army, 1998). *FM 20-32* states that minefields are used to

- Produce a vulnerability on enemy maneuver that can be exploited by friendly forces.
- Cause the enemy to piecemeal his forces.
- Interfere with enemy command and control.
- Inflict damage to enemy personnel and equipment.
- Exploit the capabilities of other weapon systems by delaying enemy forces in an engagement area.
- Protect friendly forces from enemy maneuver and infiltration. (Department of the Army, 1998, p. 2-1)

Mahoney (1996) elaborated on these uses in his examination of the role of landmines in countermobility doctrine, which focuses on the use of obstacles to delay, restrict, or stop enemy maneuver. He explained that mine warfare serves four primary purposes in countermobility operations: disruption of enemy formations and control, canalization of enemy forces, protection of friendly forces from enemy assault, and attrition of enemy personnel and equipment.

Psychological Effects

Kolasinski (1999) conducted a two-phased investigation into the psychological effects of APLs. The first phase involved a review of the open literature to determine what research had already addressed the issue. Although many references are made to the "psychological effects" of APLs, Kolasinski found very little in the open, available literature which specifically measured or documented the exact nature of the psychological effects of enemy APLs on soldiers.

The major previous work specifically addressing the psychological effects of mines discussed naval mine warfare (Greer & Bartholomew, 1986). As with landmines, Greer and Bartholomew noted that the most effective use of minefields is to control enemy forces, specifically by delaying forces or forcing them to divert from or forego their intended route. They asserted that the enemy's perception of the threat of mines is the primary mechanism by which minefields achieve their goal. Greer and Bartholomew pointed out that the fact that mines can cause serious damage makes their threat credible, but that a minefield's real effect comes from an exaggerated fear of the unknown. They asserted that the psychological effect of a minefield results from two aspects: inability to know the true threat and the risk of dire consequences associated with an underrated threat.

The scarcity of literature regarding the psychological effects of APLs necessitated a second phase by Kolasinski (1999). This phase was an exploratory investigation into

the effects of APLs on individuals who had experience with them, primarily in a non-training situation. Data were collected from current and former U.S. soldiers by means of a two-question survey which addressed the respondent's perception of both the psychological effects of APLs and their operational effects in the particular situation/conflict with which the respondent had dealt with APLs or the threat thereof.

Based on both the literature and the survey responses, Kolasinski made four primary conclusions regarding the psychological effects of APLs:

1. APLs do not always cause significant psychological effects.
2. The primary psychological effect of APLs is fear, but other emotions are also possible.
3. The major factors involved in the psychological effects of APLs are control, the inability to fight back against them, risk, and uncertainty.
4. The fear induced by APLs is most likely primarily caused by the types of injuries they inflict and the certainty of those injuries if a mine detonates.

Operational Effectiveness

As used here, the term "operational effectiveness" of APLs refers to judgments of how effective they are in fulfilling their role in military operations according to U.S. doctrine. Although the doctrinal utility of APLs is relatively objective and fairly straightforward, conclusions regarding their effectiveness at performing those tasks are not so clear. Sources for ascertaining operational effectiveness are varied, consisting of commentary in the literature and results of simulations of mine warfare. Overall, opinions about the true usefulness of APLs are very mixed and quite polarized.

Although not the focus of the study, Kolasinski (1999) explored the operational effects of APLs. Kolasinski reviewed the literature regarding operational effectiveness and provided details on several critical analyses. Data were also gathered from the sample of current and former U.S. soldiers who had experience with APLs or the threat of them in an operational situation. Based on both the literature and the survey responses, Kolasinski made four primary conclusions regarding the operational effects of APLs:

1. Typically, APLs do not completely stop a mission.
2. APLs almost always have some sort of operational effect. Overall, they constrain and slow.
3. The type of mission plays an important role in the specific operational effects of APLs.
4. A primary aspect of the operational effects of APLs is the cascading nature of their effects.
5. The exact nature of the operational effects of APLs in a given situation is a complicated function of many factors. The perceived operational effectiveness of APLs may be an important psychological effect in and of itself.

Implications for Development APL Alternatives

Based on the conclusions derived from the literature and survey responses, Kolasinski (1999) made five primary conclusions regarding the development and evaluation of APL alternatives:

1. Based on the major factors involved in the psychological effects of APLs, it is proposed that alternatives need to be a threat that the enemy would deem unable to control, would involve a high degree of uncertainty and risk, and would not allow the enemy the ability to "fight back."
2. Exact replication of the fear associated with APLs appears to hinge on the permissible lethality and maiming capability of alternatives.
3. An alternative to the exact replication of some or all of the psychological effects of APLs is replication of specific operational effects of APLs with or without the psychological ones.
4. Any APL alternative should have high efficacy in the minds of the force that is using it.
5. A paradigm shift in U.S. military strategy and operations may be the only recourse to a comprehensive ban on the use of APLs and the employment of alternatives.

Van Williams (1998) examined the role that nonlethal technologies can play in meeting the requirements for battlefield shaping and force protection. Van Williams concluded that not only can fully developed and appropriately packed nonlethal weapons replace the conventional landmine, but they can also give a commander revolutionary new options which were never possible before. Thus, as supported by Van Williams, the research by Kolasinski (1999) concluded that a comprehensive ban on the use of APLs and the employment of alternatives may, ultimately, force a paradigm shift in U.S. military strategy and operation. The Tags/Minimally Guided Munitions concept may just be one of the needed new paradigms.

The Tags/Minimally Guided Munitions Concept

The Tags/Minimally Guided Munitions (Tags/MGM) concept is a system proposed for guiding short-range indirect fire through the use of small transmitters attached to enemy soldiers. In the conceptual implementation, a tag field containing the transmitters would be emplaced at some location. As enemy soldiers traversed the field, the tags would attach themselves to the soldiers. These transmitters would have the capacity to transmit information to friendly troops regarding location of the enemy troops. Based on the location information provided by the tags, MGMs could then be aimed directly at the enemy soldiers.

In line with their doctrinal usage, much of the operational effectiveness of APLs stems from their ability to cause delay, disrupt and hinder enemy movement, and deny the enemy ground. Furthermore, APLs can also be used to direct enemy troops toward an

area where the defender is best able to defeat them – in other words, they help "shape the battlefield." Employed in this manner with other weapon systems such as direct or indirect fire, APLs have a "synergistic" effect. DARPA proposes that the Tags/MGM concept could have similar effects, especially in terms of battlefield shaping.

Obviously, implementation of the Tags/MGM concept involves many technological issues for both the Tag and MGM components. Discussion of the technological issues is well beyond the scope of this research. However, information presented at the DARPA Tags/Minimally Guided Munitions Review on 14 October 1999 indicates that both concepts are technologically feasible. In contrast, this report focuses on human factors issues surrounding the Tags/MGM concept. After discussing the issues bearing on the Tags/MGM concept, a model of the possible effects of tags on soldier behavior will be proposed.

Two Primary Issues

From the description of the Tags/MGM concept presented above, two major human factors issues initially arise: detectability of tags and behavior of tagged soldiers. As the following discussion reveals, these issues lead to further human factors issues.

Detectability of tags. The first issue of concern is whether or not enemy soldiers can detect the presence of the tags. For sake of argument, assume that it is technologically possible to make tags that are either detectable (e.g., burr-like devices) or undetectable (e.g., some type of chemical capable of transmitting information). The next question, then, is should soldiers be able to see the tags? This study argues that either option may be effective in manipulating soldier behavior but through different means.

First, consider the case of tags that are not detectable. Enemy soldiers enter the tag field and are tagged. This will, of course, not cause any immediate reaction on the part of the soldiers because they do not know that anything has happened. Unbeknownst to them, however, the tags transmit their location back to friendly forces who then aim MGMs directly at them. From the perspective of the enemy soldiers, their location has somehow been pinpointed and MGMs somehow directed at them. In the meantime, some time, t_1, has elapsed between the point when the enemy soldiers are tagged and the time at which they are hit by MGMs. When soldiers are injured or killed by the MGMs, the enemy will try to determine why they were hit by the MGMs. Once the enemy makes an attribution for the MGMs, the situation becomes like any other in which one force knows that its location is known by the other force. The likely behavioral response of and psychological effects on the enemy could be predicted based on the doctrinal response to the attributed threat. However, because the tags are not detectable, it may take considerable time before the enemy determines the exact details of the Tags/MGM system. During this time, t_{1a}, the enemy may expend much time and effort either trying to figure out the exact mechanism or combating the wrong mechanism. A variety of behavioral and psychological effects may occur until the exact mechanism is determined.

Next, consider the case that the tags are detectable but assumed to be so small that they can only be detected at very close range, most likely only once they have become attached to a soldier. In other words, enemy soldiers would not be able to visually identify a tag field from a distance. This case has two sub-cases: either the effect of the

tags is known (i.e., enemy soldiers know that being tagged means that MGMs will soon be directed at them) or it is unknown.

First consider the case in which the effect of the tags is unknown. Enemy soldiers enter the tag field and become tagged. If the tags are not immediately noticed, there will be no immediate reaction on the part of the soldiers. As MGMs start to come in, however, the enemy forces will have to make an attribution for the incoming MGMs. As in the case described above, friendly forces have gained the advantage of time t_1.

An alternative case is that in which the effect of the tags is unknown and the tags are noticed. The attention of enemy soldiers will likely be diverted to some degree as the soldiers inspect the tags and, possibly, try to remove them. If they are successful in removing the tags before they can signal back to the MGMs, the tags will have had no effect and the enemy will still not be knowledgeable about the Tags/MGM system. If the enemy soldiers are not successful in removing the tags and, thus, draw MGMs, the tagged soldiers will be injured or killed either with or without accomplishing the mission objective and the remaining soldiers will have to make an attribution for the incoming MGMs. As in the case above, friendly forces have gained the advantage of time t_1.

Lastly, consider the case in which the tags are detectable and their effects are known. Again, also consider the two sub-cases in which the tags are either noticed or not noticed by the tagged soldier. In either case, the only time advantage gained by the friendly forces is time t_2, the time between the tagging of the enemy forces and their noticing the tags. Note that this time may be either less than or equal to time t_1 (the time from tagging to being hit by an MGM). If it is less than t_1, then the issue becomes one of tag removability, which is discussed in the next subsection. If t_2 is equal to t_1, the tagged soldiers are injured or killed either with or without accomplishing the mission objective, but, because the effect of the tags is known, the remaining soldiers can infer the presence of tags and the issue becomes tag detectability and removability. The alternative case in which the tagged soldier notices the tags is discussed in the next subsection.

Soldier behavior. The second issue directly follows from the cases presented above. Recall that in the first case (tags not detectable), soldiers know that, somehow, the opposing force can pinpoint their location and direct a weapon at them. A likely attribution would be some sort of indirect fire (such as field artillery) due to the similar effects. How they will behave in this situation will ultimately be determined by doctrine and, until the tag mechanism is determined, behavior may be based upon a faulty attribution for how the opposing force knows the enemy's location.

The second case, in which the tags are detectable, has two sub-cases in which the effect of the tags is known or unknown. Ultimately, regardless of whether the soldier initially notices and successfully removes the tag (i.e., before MGMs come in) it can be assumed that the sub-case of the unknown effect will eventually become the case of known effect either through direct experience with the Tags/MGM system or through enemy intelligence. Furthermore, the case in which the effect of the tags is known and the tag is not initially noticed will, eventually, become the case in which the tags is noticed. Thus, for the sake of this report, the case of most interest is that in which the tags are detectable, their effect is known, and the tags are noticed.

Consider a situation in which enemy soldiers enter the tag field, become tagged, and, after some time t_2, realize that they are tagged. Because it is assumed that the effect

of the tags is known, the soldiers know that MGMs will soon be headed their way. What do they do? Mostly likely, the first logical action would be to try to remove the tag. At this point, the significant issue becomes whether or not the tags can be removed.

Assume first that the tags can be removed. The next questions become whether or not the soldier knows that the tags can be removed and whether or not the soldier tries to remove the tag. Suppose that the soldier does not know that the tags can be removed and does not try to remove them. Ultimately, the soldier will be injured or killed by an MGM either with or without accomplishing the mission objective. Because the effects of the tags are known, behavioral and psychological effects may occur given that the soldier knows that injury or death is impending.

Now suppose that the soldier does not know that the tags can be removed but does attempt to remove them. The next question is whether or not the soldier successfully removes the tag before being injured or killed by an MGM. If the soldier is not successful, injury or death will result. If the soldier is successful, injury or death may be avoided and the soldier will know for future encounters that the tag is removable. Either way, because the effect of the tags is known, behavioral and psychological effects may occur during the time, t_3, it takes to either remove them or be hit by an MGM. Furthermore, if the tag is successfully removed, the effects may or may not end once the tag is removed. Tied in with this issue will be how easy the tags are to remove. If they can be easily removed by, say, brushing them off the uniform, then t_3 will be relatively short and, most likely, fairly free of behavioral and psychological effect. If they are difficult to remove, perhaps by requiring the soldier to cut off pieces of the uniform, the skin, or the body, then t_3 could be relatively lengthy and may involve severe behavioral and psychological effects.

Alternatively, suppose that the soldier knows that the tags can be removed. Again, the questions are whether or not the soldier tries to remove the tag and whether or not it is successfully removed before the soldier is injured or killed by an MGM. The outcomes in all three situations are similar to the three outcomes described above.

The above situations have involved removable tags. Now consider the case of unremovable tags with known effect. Again, the first question is whether or not the tagged soldier knows that the tags are unremovable. Assume that the soldier does not know this. The next question is whether or not an attempt is made to remove the tag. Either way, the soldier will be injured or killed by an MGM either with or without accomplishing the mission objective because the tag cannot be removed. The behavioral and psychological effects, however, may differ depending upon whether or not an attempt is made to remove the tags.

Lastly, consider the case of an unremovable tag with known effect and which is known to be unremovable. The soldier is faced with being tagged, knowing that MGMs will soon be arriving, and knowing that there is no way to remove the tag and, hence, no way to avoid injury or death from the incoming MGM. This case may or may not be feasible but would likely lead to the most severe behavioral and psychological effects.

A Proposed Model of Tag Effects on Soldier Behavior

The various cases and results discussed in the previous section can be summarized in the following Tag Behavioral Effects Model (TBEM).

The Tag Behavioral Effects Model (TBEM)

Is the tag detectable?

1. **No.** *Result: Time t_1 elapses until MGMs arrive and tagged soldiers are injured/killed either with or without accomplishing the mission objective. After being hit by incoming MGMs, the enemy makes an attribution for the MGMs.* **Does the enemy make the correct attribution regarding the source of the incoming MGMs?**
   - *1.1.* **No.** *Result: Likely behavioral and psychological effects can be predicted based on the doctrinal response to the attributed threat.*
   - *1.2.* **Yes.** *Result: Determination of the exact nature of the tags may take additional time t_{1a} during which behavioral and psychological effects may occur. After this time, remaining soldiers will have familiarity with the Tags/MGM system.*
2. **Yes. Is the effect of the tags (i.e., incoming MGMs) known?**
   - **2.1. No. Does the soldier notice the tag?**
     - **2.1.1. No.** *Result: same as 1.*
     - *2.1.2.* **Yes.** *Result: Time t_1 or less elapses. During this time, soldier attention is possibly diverted as soldiers inspect tags and/or try to remove them. Minor behavioral and psychological effects may occur.* **Are the tags successfully removed before MGMs arrive?**
       - *2.1.2.1.* **Yes.** *Result: soldiers will not know the effect of the tags for future encounters.*
       - *2.1.2.2.* **No.** *Result: MGMs arrive, tagged soldiers are injured/killed either with or without accomplishing the mission objective, and the result is the same as 1.*
   - **2.2. Yes. Does the soldier notice the tag?**
     - *2.2.1.* **No.** *Result: Time t_2 elapses. If t_2 is less than t_1, tagged soldiers go to 2.2.2. If t_2 is equal to t_1, tagged soldiers are injured/killed either with or without accomplishing the mission objective but the remaining soldiers can infer the presence of tags and they go to 2.2.2.*
     - **2.2.2. Yes. Is the tag removable?**
       - **2.2.2.1. Yes. Does the soldier know the tag is removable?**
         - **2.2.2.1.1. No. Does the soldier try to remove the tag?**
           - *2.2.2.1.1.1.* **No.** *Result: A – possible behavioral & psychological effects*
           - *2.2.2.1.1.2.* **Yes. Is the soldier successful in removing the tag?**
             - *2.2.2.1.1.2.1.* **No.** *Result: B – possibly large behavioral & psychological effects*
             - *2.2.2.1.1.2.2.* **Yes.** *Result: C – possible behavioral & psychological effects; in addition, soldier now knows that the tag is removable*
         - **2.2.2.1.2. Yes. Does the soldier try to remove the tag?**
           - *2.2.2.1.2.1.* **No.** *Result: A – possible behavioral & psychological effects*
           - *2.2.2.1.2.2.* **Yes. Is the soldier successful in removing the tag?**
             - *2.2.2.1.2.2.1.* **No.** *Result: B – possibly large behavioral & psychological effects*
             - *2.2.2.1.2.2.2.* **Yes.** *Result: C – possible behavioral & psychological effects*
       - **2.2.2.2. No. Does the soldier know the tag is not removable?**
         - **2.2.2.2.1. No. Does the soldier try to remove the tag?**
           - *2.2.2.2.1.1.* **No.** *Result: A – possible behavioral & psychological effects*
           - *2.2.2.2.1.2.* **Yes.** *Result: B – possibly large behavioral & psychological effects*
         - *2.2.2.2.2.* **Yes.** *Result: D – possibly severe behavioral & psychological effects*

Result A: Ultimately, the soldier is injured/killed by an MGM either with or without accomplishing the mission objective. Because the effects of the tag are known, psychological and behavioral effects may occur.
Result B: Ultimately, the soldier is injured/killed by an MGM either with or without accomplishing the mission objective. Because the effects of the tag are known, large behavioral and psychological effects may occur while the soldier attempts unsuccessfully to remove the tag.
Result C: After some time t_3, the tag is removed. Because the effects of the tag are known, behavioral and psychological effects may occur while the soldier removes the tag. The magnitude of such effects will likely depend upon the ease of tag removal. These effects may or may not end once the tag is removed.
Result D: Ultimately, the soldier is injured/killed by an MGM either with or without accomplishing the objective and regardless of whether an attempt is made to remove the tag. Because the effects of the tag are known (i.e., the soldier will be hit by an MGM) and the soldier knows it cannot be removed, severe behavioral and psychological effects may occur until the soldier is injured/killed. Because the feasibility of making a tag that cannot be removed is unknown, this result may or may not be possible.

Human Factors Considerations for the Tags/MGM Concept

The TBEM presented in the previous section allows for identification of the major human factors issues involved in the Tags/MGM concept. As these issues are discussed below, relevant literature from the open, available literature base (i.e., journal articles, technical reports, and other such documents that are indexed by major databases and readily obtainable) is also discussed.

Tag Characteristics

Some of the human factors considerations of the Tags/MGM concept do not involve the soldier at all but, rather, aspects of the tag device.

Detectability. The first consideration in the TBEM is the detectability of the tag itself. In other words, can soldiers see, smell, feel, or somehow detect the presence of a tag? Assume that it is technologically possible to make a tag that is not detectable. How would this impact soldier behavior? Would it more beneficial for the tags to be detectable?

Referring back to the TBEM, a tag that is not detectable does not appear to be advantageous in introducing any new psychological or behavioral effects onto the battlefield. As MGMs start to make contact with enemy soldiers, the enemy will attempt to determine how their position has been located. Assume that a tag can be developed which is completely undetectable so that the enemy would never determine that their location is being given away by tags. Certainly this would add an advantageous element of confusion into the enemy's thought process. However, nothing especially new has been introduced by the use of the tags except for a way to pinpoint the enemy's location. Ultimately, the enemy's behavior will depend upon what they think is responsible for giving away their location. The primary benefit to the friendly force is the enemy's confusion. If the tags are eventually detected, the benefit is the time the enemy has spent reacting incorrectly. If, however, the tags are detectable – perhaps after some amount of time – then many additional issues arise and are discussed below.

Note, however, that detectability is not necessarily an all-or-none issue. At the DARPA Tags/Minimally Guided Munitions Review on 14 October 1999, several tag designs were offered which, although unquestionably visible to the naked eye, were difficult to detect, especially against the pattern of a camouflage uniform. Such designs would appear to offer the best of both possibilities of the detectability issue: tiny enough to be difficult to detect without introducing an unrealistic "undetectable" requirement into the design. Thus, detectability is a continuum that engenders different effects on the enemy.

Note also that "detectable" is not necessarily the same thing as "visible." In the case of a tag transmitted in a gas, for example, the tag may be a residue. A tag of this sort may not be visible but may be detectable through an odor or with a special sensing device such as a black light or a Geiger counter.

Removability. The second tag-related issue which must be considered in determining the effect of the Tags/MGM concept on soldier behavior is whether or not

the tags can be removed. Although technical aspects of tags are not the focus of this report, the technical feasibility of developing a tag that is not removable is not a trivial matter. Is it possible to make a tag that is not removable? Assuming that it is possible, is it desirable in terms of the resulting effects?

Removability is important because it manipulates an important aspect of any potential weapon: soldier control. Recall that Kolasinski (1999) found that one of the important aspects of APLs is that soldiers feel they cannot control the threat or fight back against it. The role of control in ameliorating stress is also supported by the literature (e.g., Cohen, 1980). Additional research has found that anticipation of dangerous or threatening situations and lack of control over them decreases performance (Orasanu & Backer, 1996).

Fighting back is an important way for soldiers to cope with stress. Suppose, for example, that tagged soldiers were able to remove the tags and throw them back at the enemy to let the MGM direct to the enemy. Such a situation might represent a way in which the enemy could fight back against the tags and exert important stress-reducing control against the tag threat.

Referring back to the TBEM, the most severe psychological and behavioral effects are predicted to result when the tags are not removable. This prediction is supported when one considers that an unremovable tag would be a threat that the soldier would be wholly unable to control. However, one Army military intelligence officer interviewed for this report argued that except for, possibly, some sort of skin-penetrating chemical or other such type of tag, it may not be possible to make an unremovable tag. This officer warned that tag designers may underestimate the lengths to which soldiers might go to remove a tag. He stated that anything that soldiers know is somehow attached can be removed given that, under extreme situations, people will act out of desperation and in unconventional ways. If tags attach to clothing, removal could be as simple as brushing them off or cutting off the clothing to which they are attached. If tags attach to skin, removal may be more complicated – and, perhaps, grisly – but the officer argued that soldiers would even to be willing to cut off skin if necessary to avoid injury or death from an incoming directed MGM.

Two important issues which interact with removability are how easily the tag can be removed and whether or not tagged soldiers know the result of being tagged (i.e., directed MGMs). Both of these issues are discussed further below.

Ease of removal. For the sake of argument, assume that it is not possible to make an unremovable tag. Thus, any tag discovered by a soldier can be removed somehow. The next question, of course, is what does removal entail? Tags that adhere to clothing may, conceptually, require various degrees of removal effort, ranging from brushing off to carefully picking off to cutting out the clothing. Tags that adhere to skin may also require various degrees of removal effort, ranging from abrading to cutting off the skin. Obviously, requirements to cut off skin introduce a grisly element into the situation and soldiers may be reluctant to take such an action and inflict self-harm. At some level, very difficult or grisly to remove may be essentially the same as unremovable. However, the willingness of soldiers to inflict harm on themselves would very likely be a function of whether or not they know the ultimate outcome of being tagged.

Note that detectability issues come into play as well. It would not matter if a tag need only be brushed off to be removed if it is difficult or impossible to detect. Thus, in terms of removal effort, an extremely tiny tag that can simply be brushed off may be essentially as difficult to remove as an easily seen tag that needs to be cut out of skin or clothing. As with detectability, then, ease of removal is not an all-or-none issue either but, rather, an aspect that interacts with detectability.

Knowledge of the Tags/MGM System

The previous subsections have discussed tag design characteristics that will impact the ultimate enemy response to the Tags/MGM system. Several aspects of the enemy soldiers also come into play as important human factors considerations. The next category of human factors issues involved in determining the behavioral and psychological effects of the Tags/MGM system concerns enemy knowledge. Enemy knowledge is not something tag designers may be able to specifically impact, but it is something of which they need to be aware.

Enemy attribution and subsequent response. The first of these is the initial enemy response, the attribution they make for the incoming MGMs. If the enemy is aware of the existence of the Tags/MGM system through intelligence, previous experience, or some other method, then the attribution will likely be relatively straightforward: the MGMs are due to tags.

If, however, the enemy is not aware of the Tags/MGM system, they will still attempt to determine how their position is being detected. Possible attributions based on existing systems include unmanned aerial vehicles, a forward observer, or satellite imaging. As noted in the TBEM, the subsequent enemy response could be predicted based on the doctrinal response to the attributed threat.

Knowledge of the tag effect. The first type of knowledge of interest in assessing the potential Tags/MGM effect is whether or not the enemy knows the effect of being tagged. Specifically, is the enemy soldier aware that being tagged results in a target-directed MGM? In other words, is the enemy soldier aware that being tagged means imminent injury or death? The TBEM proposes different effects based on whether the soldier has this knowledge. Indeed, Orasanu and Backer (1996) noted that the effects of the threat of danger or physical harm depend upon how strongly individuals believe in the threat of death or injury. It can be assumed, however, that the tag effect will eventually be known either though observing the results of tagging from fellow soldiers, through intelligence gathered about the opposing force, or through knowledge of the Tags/MGM system, should its use become widespread.

Knowledge of removability. It was discussed earlier that the removability of the tag is a characteristic that must be considered in evaluating the potential Tags/MGM effect. Regardless of whether or not the tag is removable, an important related issue is whether or not the enemy soldier knows if the tag can be removed. This knowledge, however, is also tied in with knowledge of the tag effect and it can be assumed that

knowledge of tag removability will eventually be gained either though experience, intelligence, or widespread use.

Behavior of Tagged Soldiers

In an effort to consider the possible psychological and behavioral effects of the Tags/MGM concept, the previous sections proposed several human factors issues. The ultimate question, however, is how do soldiers behave if they know they are tagged? The Tags/MGM concept is proposed as an alternative to APLs for shaping the battlefield by manipulating soldier behavior. Thus, an important question is whether or not tagging soldiers would have the capability to affect the behavior of soldiers.

Attention drawn to tag. A previous section introduced the issue of tag detectability. Tied in with this issue – but also separate from it – is whether or not the soldier notices the tag. In other words, is the soldier's attention drawn to the tag? Several factors could impact whether or not the soldier notices the tag. First, the tag may be so small and inconspicuous that it is not easily detectable without close inspection. Thus, noticing the tag is likely heavily dependent upon its detectability.

Second, attention is a limited resource (e.g., Wickens, 1992) – humans can only pay attention to a limited number of things at any given time. The battlefield is undoubtedly a place of abundant stimuli that make many constant demands on a soldier's attention. Internal soldier states (e.g., amount of sleep, hunger, fear) compete with external demands (e.g., the mission, the environment, other soldiers) to create a situation of high mental workload. Even if a soldier notices a tag on the uniform, further attention may not be given to the tag unless the soldier knows exactly what the tag is and the resulting effect. Soldiers who are focused on accomplishing their current task may not even notice the tags in the first place because their attention is focused elsewhere.

Finally, fear – and stress and anxiety in general – causes a narrowing of attention (National Research Council, 1998). In the case of tagged soldiers who know they are tagged, fear and anxiety may result in narrowed focus on the tag in an attempt to remove it. Alternatively, it may also cause a narrowed focus on the objective in a "kamikaze" type of mentality. Other responses could, of course, also be possible.

Ultimately, however, as indicated in the TBEM, attention will be drawn to the tags either because the soldier explicitly notices them or because incoming MGMs alert the soldiers to their presence.

Removal attempt. Assuming that a tagged soldier notices the tags in time to remove them before they draw MGMs, the next question is do they attempt to remove them? The answer to this is likely a function of several factors: whether or not the soldier is familiar with the Tags/MGM system and knows the effect of being tagged, whether or not the tags are removable, and whether or not the soldier knows about the tag removability.

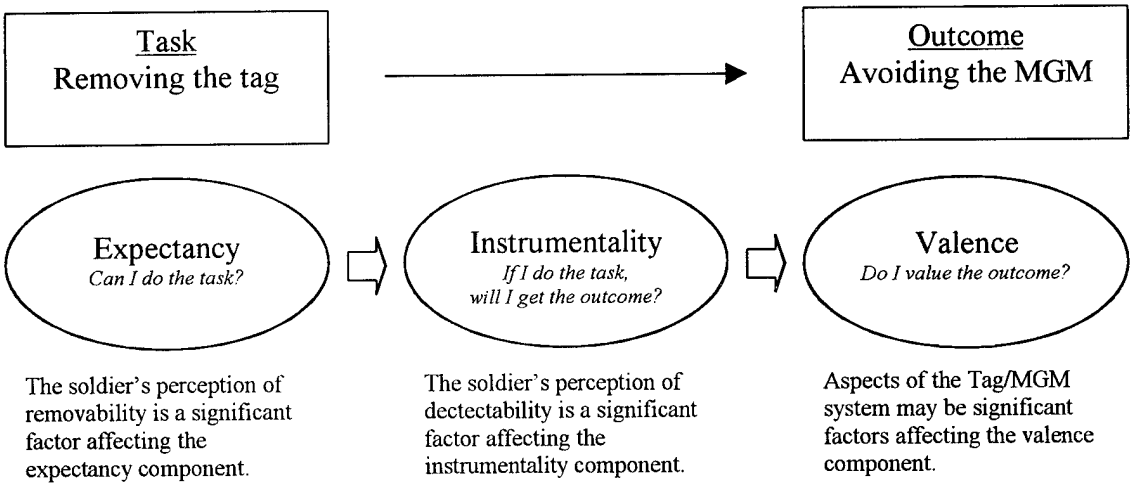
Whether or not a tagged soldier attempts to remove the tag is an important issue in assessing the potential effects of the Tags/MGM concept because it represents the only real decision element in the TBEM. As such, it is the only real point at which the Tags/MGM system will exert any behavioral or psychological effects.

Recall that control is an important aspect in a soldier's evaluation of a threat or stressor. If the soldier determines or knows that tags are a threat that can be controlled, that control will be exerted in the decision regarding their removal. Depending upon the ease of removal, tagged soldiers may be able to exert direct control over the tags by simply removing them. Knowledge of removability and ease of removal, however, also introduce an important element into the decision process, especially if the soldier knows the effect of being tagged. Specifically, the decision to remove the tags becomes a weighing of trade-offs: time to clear the tags versus the effects of not clearing them. Suppose the tag is such that removal of it requires removal of skin. In such a case, soldiers may be highly averse to removing it even if they know that they can avoid injury or death by inflicting such self-harm.

Several models exist in the literature to explain motivation to perform tasks. One such model is Vroom's (1964) expectancy theory. This model proposes that motivation to accomplish a task is a function of three components: expectancy (belief in the ability to accomplish the task), instrumentality (belief that accomplishing the task will result in a specific outcome), and valence (the value placed on the outcome). Vroom proposed that motivation to perform a given task will be at its highest when all three components are at their highest. Alternatively, if all three components are low, motivation will be low. Various combinations of the three components result in various levels of motivation. In some cases, motivation may be high because one component is very high relative to the other two. It could also happen that motivation may be low because one component is very low relative to the other two.

Expectancy theory can be used to predict a tagged soldier's motivation to remove tags as is illustrated in the figure below.

Application of the Expectancy Theory of Motivation to the Tag/MGM System



In the case of a tagged soldier, the task is successfully removing the tags before being hit by an MGM and the outcome is avoiding injury or death. Valence would, undoubtedly, be high as soldiers are likely to place high value on survival. Expectancy and instrumentality, however, are functions of the tag design. Expectancy would be a

function of both the actual removability of the tag as well as the soldier's knowledge regarding the removability. If the soldier knows or believes that the tag is not removable or that it is very difficult or grisly to remove, expectancy may be very low. Resulting motivation in this case may be low even though valence is high.

Instrumentality is a function of the detectability aspect of the tag design. The tag designs proposed at the DARPA Tags/Minimally Guided Munitions Review on 14 October 1999 were all extremely small and hard to detect. In field tests of the design, a soldier traversing a tag field was tagged by multiple tags rather than a single tag. Furthermore, it was not always easy to immediately spot all of the tags which had attached themselves: in some instances, researchers thought they found all the tags on the soldier's uniform, only to later discover that additional tags had also adhered to the solder's uniform. Recall that, in terms of the expectancy model, instrumentality would be a function of how certain the soldier was that removing the tags would result in avoidance of injury or death. If soldiers are typically tagged by multiple tags and the tags are hard to detect, it would likely to be hard to know whether all of the tags had been removed. Thus, for the tagged soldier trying to decide whether to attempt to remove the tags, there would likely be no guarantee that removing the detectable tags would result in avoidance of injury or death because additional tags may remain. Thus, instrumentality may not be high. Coupled, as discussed above, with possibly low expectancy, overall motivation to remove the tags may be low. However, it could also be proposed that high valence on survival may work to drive motivation. Clearly, this is a difficult situation for the soldier – and one likely to cause much fear, anxiety, and stress. However, regardless of the soldier's ultimate decision regarding tag removal, operationally, time focused on deciding whether or not to clear one's uniform is important because it is time not spent on accomplishing the mission and task at hand.

Additionally, those factors which result in a greater likelihood of low motivation to remove the tag (such as low removability, low detectability, and low ease of removal) will also strongly influence the operational effectiveness of the Tag/MGM system. Soldiers and units who are unwilling to remove tags may be more likely to exit the tag field. In contrast, soldiers who are willing to remove the tags may waste time, but may not be deterred as they would have been in a minefield. However, if a unit decides that tag removal is too costly of a way to avoid MGMs, they might also decide that continued maneuver through the tag field is similarly too great a burden.

A discussion with an infantry officer provided some insights into the possible soldier decision regarding tag removal. First, the officer stated that he would be more likely to take the time to clear his uniform if he witnessed another unit get hit due to the tags. This directly reflects the importance of knowledge of the tag effect. The officer also predicted that effectiveness of the tags in terms of battlefield shaping would be reduced as the soldiers came closer to contact. In other words, soldiers that were close to meeting the mission objective may simply rush the target in a kamikaze manner, regardless of their impending fate. The officer added that effectiveness of tags as battlefield shapers would increase in a low intensity environment due to the sustained psychological effects.

The comments of this officer point to several issues that must be considered in trying to predict the effects of the Tags/MGM system on soldier behavior. First, as noted earlier, people in extreme situations may act in extreme ways. That some tagged soldiers

may adopt a kamikaze mentality is probably not unrealistic. Leon (1987) noted that aggression is one method of dealing with battlefield stress. It is not unlikely that some tagged soldiers would deal with the stress of being tagged by aggressing toward the enemy in a kamikaze action. Second, Kolasinski (1999) noted that the type of mission plays an important role in the specific operational effects of APLs. The same may be true of the Tags/MGM system as well. Specifically, soldiers may be more willing to engage in kamikaze behavior in a wartime situation but, in a peacekeeping operation, they may be more willing to take the time to thoroughly clear their uniform or to try to avoid the tag field. Furthermore, in a war time situation, willingness to engage in kamikaze behavior would also likely be a function of how close the soldiers were to accomplishing the mission. If a unit encountered a tag field early in the mission, soldiers may be unwilling to die "in vain." In contrast, if a unit encountered a tag field when they were very close to accomplishing the mission, soldiers may be more willing to trade their lives for mission success. This, of course, has potential implications for operational use of tag fields and suggests that they not be effective for close proximity protection. Finally, the effects on untagged soldiers – especially the effects of repeated experiences with tags – must also be considered.

Behavior after being tagged. So enemy soldiers enter a tag field and become tagged. Assume they are aware they are tagged and they know that being tagged means impending injury or death from direct MGMs. What do they do? How do they behave?

The previous subsection addressed the decision element for the tagged enemy soldier: deciding whether or not to try to remove the tags. As already noted, even if the tags can be completely cleared from one's uniform, the tags have served an important operational purpose in that they have forced the enemy to divert attention and time from the mission in order to clear the tags. Ease of removal is an important issue at this point because tags which can be easily removed will not require a significant investment of time – the soldier could simply clear the tags and "drive on" with the mission.

Tags that cannot be easily removed, however, cost the enemy precious time but may also play an important role in inducing important psychological and behavioral effects on the enemy. Consider the situation of tagged soldiers who are desperately trying to clear tags from their uniforms because they know that MGMs are directed at them and on their way. As time and effort are expended in an unsuccessful or difficult clearing attempt, how do the soldiers react? Do they become increasingly desperate and stressed and completely break down mentally? Do their futile efforts lead to a sort of "learned helpless" in which they decide that there is nothing they can do to escape their fate and they simply give up trying? Or does their frustration lead to a kamikaze mentality in which they decide to ignore the tag and try to "drive on" and accomplish the mission objective, regardless of the personal result to them?

The general issue is how soldiers react to stress and how, if at all, stress impacts their performance. The specific issue is how soldiers react in the face of impending injury or death and how, if at all, impending injury or death alters their behavior. There is a large literature base on stress and its effects on human performance. However, as Orasanu and Backer (1996) noted in their review of the stress literature as it applies to military performance, not all of the stress effects literature is relevant to combat performance and training. The case of a tagged soldier who knows that injury or death is

imminent is an especially unique case for which there is little – if any – directly relevant literature.

Probably the best known – although not universally accepted – model of the thoughts and behavior of the dying person is offered by Kübler-Ross (1969; cited in Santrock, 1997). Kübler-Ross divided the thoughts and behavior of the dying person into five stages: denial and isolation, anger, bargaining, depression, and acceptance. Research suggests that people may go through the stages in different orders and that not all dying people go through all of the stages. Furthermore, Fraser (1983) noted bargaining is often eliminated in the case of sudden death, the case most likely in a military situation.

Unfortunately, the literature is sparse on experimental studies of the attitudes and behaviors of people faced with death from such unnatural causes as tags. The closest study uncovered in the literature is that of Bluestone and McGahee (1962) who studied 19 prisoners in the Sing Sing death house for up to two years before their death. They found that, contrary to what one might expect, the prisoners, faced with certain death, were not overwhelmed with anxiety and did not plunge into deep depression. Instead, they found that the prisoners engaged in three primary defenses: denial, projection, and obsessive rumination. Denial, as noted by Bluestone and McGahee, is commonly used by persons dying of disease and, in their study, denial took several forms. The two most common forms they found were isolation of affect (a "so they'll kill me, and that's that" attitude) and a minimization of the gravity of the present situation. Another denial-like phenomenon they noted with one prisoner was that of becoming intensely immersed in the present moment, insulated from any significant emotional relatedness with his own past or future. The prisoners also engaged in projection, typically in the form of persecutory delusions, which Bluestone and McGahee noted converted the criminals into martyrs in an effort to lend their impending death dignity and meaning. Bluestone and McGahee's third type of coping mechanism involved furiously thinking about something else: obsessive concern about preparing appeals or pleas for clemency, preoccupation with religion to the exclusion of everything else, or intellectual, philosophical ruminating. Some prisoners desperately tried to mold a respectable image of themselves. Bluestone and McGahee noted that religious obsession appeared to distract the prisoners from anxiety and offered a route to a happy life in the hereafter. Although Bluestone and McGahee's study focused on convicted criminals, their results lend some insight into the possible response of tagged soldiers facing an incoming MGM. Specifically, it is relatively easy to see how many of the responses noted by Bluestone and McGahee could lead to a kamikaze effort among at least some soldiers.

So what does this collection of findings imply about how tagged soldiers might behave? It is well established in the psychological literature that large individual differences exist among people on virtually any given behavior. Thus, it is wholly expected that large individual differences would also exist among soldiers in a tagged situation. Cultural issues would also likely come into play as well. Some soldiers may focus on trying to remove the tags while others may assume a kamikaze role. For others, being tagged may be a final stressor in an accumulation of stressors and may lead to breakdown. Thus, the clearest implication from the literature is that a variety of responses are likely among tagged soldiers.

Behavior of Untagged Soldiers

All discussion so far about the potential effects of tags on enemy soldiers has focused on the effects of soldiers who are tagged. But what about the effects on soldiers who are not themselves tagged but who know that their comrades are tagged? Although not represented in the TBEM, the effects on untagged soldiers may be the most important aspect of the Tags/MGM concept. In the case of unremovable tags, the effects on tagged soldiers are relatively short-lived. As discussed in the previous section, tagged soldiers may engage in a variety of responses from expending time removing tags to escalating into a Kamizakee mode. Although the tagged soldier is ultimately injured or killed by the MGM, the untagged comrades remain – and what is the effect on them?

Helping behavior. Consider a situation in which enemy soldiers enter a tag field and some of them become tagged. What about the behavior of soldiers who are not themselves tagged but who know that their comrades are tagged? Do they try to help their fellow soldiers? If they know the tags are not removable and know that MGMs will soon be incoming on possibly nearby fellow soldiers, how do they react?

An extensive literature base exists on the topic of helping behavior in emergency situations. Additional literature also exists specifically on crowd behavior. Several models exist but the overall finding is that, in order for a person to help in an emergency, the person must notice the incident, assume some degree of responsibility for helping, and be able to help. Ironically, the bystander effect demonstrates that the more people that are present in an emergency, the less likely a person is to receive aid, largely because of a diffusion of responsibility in which everyone assumes someone else will render aid.

The findings regarding helping behavior, however, relate primarily to people helping strangers, often in an impersonal crowd situation. Unfortunately, the relevance of this literature to the battlefield is likely to be low. The important consideration for the battlefield is that a unit of soldiers is not an impersonal crowd but, rather, a highly cohesive group. As such, soldiers could be expected to be concerned about the welfare of their comrades. Thus, helping behavior is likely to be very high among soldiers in an emergency situation.

However, consider the situation once again. Untagged soldiers know that tagged comrades will be hit by a directed MGM. If the tags are removable, untagged soldiers would likely engage in helping behavior and attempt to help clear their comrade's uniform. However, if the tags are difficult or impossible to remove, the most advantageous action in an operational sense may be for untagged soldiers to abandon their tagged comrades in order to avoid being hit by incoming MGMs themselves in an effort to continue with the mission objective and, hence, maximize the chance of mission success. This, however, clearly runs counter to the helping behavior that would be expected for a highly cohesive group and would likely cause extreme stress among both tagged and untagged soldiers. In addition, it would also force the enemy soldiers to widen their formation in order to put physical distance between the tagged and untagged soldiers.

Cumulative effects. The infantry officer interviewed for this project indicated that he predicted he would be more likely to take the time to clear his uniform of tags if he witnessed another unit get hit due to the tags. This directly reflects the importance of both knowledge of the tag effect and cumulative effects of exposure to the Tags/MGM system. It was noted in the previous subsection that untagged soldiers may not be able to aid their tagged comrades, and that this is likely to cause anxiety among untagged soldiers. As tagged soldiers are injured or killed, their untagged comrades may experience a form of "survivor guilt" because they could not, should not, or did not help them. Alternatively, untagged soldiers may simply become numb. Cohen (1980) reviewed the literature on the effects of uncontrollable stress on social behavior and concluded that a decreased sensitivity to others (e.g., decreased helping, increased aggression) follows from exposure to unpredictable and uncontrollable stress. Regardless of the ultimate effect, the important control factor has been manipulated once again.

Leon (1987) discussed many causes of battlefield stress and identified both fear and loss of comrades as contributors to battlefield stress. Leon also noted that group support and cohesion is an important coping mechanism for dealing with battlefield stress. Thus, adding witnessing comrade death to lack of control to help sets the stage for a significant increase in stress and decrease in morale among untagged soldiers. This could lead to additional behavioral effects (e.g., removal efforts) and corresponding psychological effects should those soldiers themselves ever become tagged.

Applications and Areas for Future Research

Overall, this report has raised many more questions than it has answered. Hopefully, it provides a human factors perspective on the Tags/MGM concept that may not have been previously considered but which may identify important issues for the developers of the Tags/MGM system. Because the Tags/MGM system is still in the conceptual stage, the findings of this report also represent areas for future research.

Potential Design Considerations

Detectability, removability, and ease of removal are three design characteristics of the tags that are proposed to have an effect on soldier response to tags. Clearly these issues are dependent upon technology but, as noted, they need not be thought of in all-or-nothing terms. It may not be technologically possible to make an undetectable tag; however, a tag that is very hard to detect may have the same effect. Likewise, it may not be possible to make an unremovable tag, but a tag that is difficult to remove may be just as effective. Indeed, the ease of removal factor is likely to be especially important because of the hypothesized role in inducing panic and anxiety.

Overall, it would appear that any characteristic of tags that introduces uncertainty into the situation will only increase the potential psychological and behavioral effects. What if some tags could be removed and others could not? Additional uncertainty would be introduced because soldiers would need to expend time and attention trying to determine if a tag were removable. Then, they would need to weigh this time against the possibilities of not removing the tag. Furthermore, employing an expectancy model to

predict soldier motivation to remove the tag, uncertainty over removability would manipulate the expectancy component of the soldier's motivation – the soldier would be unsure if the tag removal task could be completed.

What if some tags were detectable and some were not detectable? In such a situation, soldiers might remove the detectable tag but the undetectable one would remain. Deferring again to an expectancy model, instrumentality would be affected – the soldier would be unsure if completing the tag removal task would result in avoidance of injury or death.

An additional method of introducing uncertainty into the situation would be to vary the tag-to-MGM ratio. In other words, some tags would draw MGMs but some would not. Such a situation would appear to be especially effective in introducing uncertainty because then tagged soldiers knows that time spent clearing their uniform may be completely wasted if the tags do not draw MGMs. In terms of the expectancy model, the valence component is affected because the outcome is uncertain: tagged soldiers may or may not get hit by an MGMs.

Note that all of the issues discussed above ultimately hinge on the enemy's proper attribution regarding incoming MGMs as well as their knowledge about the Tags/MGM system. These are elements that may or may not be able to be controlled but need to be considered.

Potential Psychological and Behavioral Effects

The Tags/MGM concept is proposed as an alternative method of battlefield shaping. The questions that prompted this report were whether or not a Tags/MGM system could produce area denial and whether or not the effects on soldiers would mimic those of APLs. Based on the observations made in this report, this researcher concludes that the Tags/MGM concept could definitely produce psychological and behavioral effects on enemy soldiers. But would those effects mimic those of APLs?

It was noted that enemy knowledge of the Tags/MGM system would likely play a major role in the soldier response to being tagged. Although some effects may occur during the time when the enemy is trying to determine the nature of the system, tags would wield their greatest effects when the enemy understands how the system works. Indeed, knowing about the effect of being tagged is the primary mechanism through which the weapon would work.

Recall that Kolasinski (1999) concluded that the primary psychological effect of APLs is fear, most likely primarily caused by the types of injuries they inflict and the certainty of those injuries if a mine detonates. Although tags would not likely cause the same sort of fear, they would certainly introduce additional fear and anxiety onto the battlefield. With APLs, the fear appears to be largely due to fear of impending injury. With tags, however, the fear would likely be due largely to knowledge of impending death. Note, however, that both weapons share an element of certainty: if a soldier steps on an APL, some sort of injury is certain; if a soldier is tagged, an incoming directed MGM is certain.

Kolasinski also concluded that the major factors involved in the psychological effects of APLs are control, the inability to fight back against them,

risk, and uncertainty. Depending upon design aspects such as detectability and removability, it appears that the Tags/MGM system could potentially replicate all four of these factors. Both APLs and tags are threats that the soldier cannot control or fight back against. Tag removability is a method for manipulating the control the soldier has over the threat. On the one hand, the soldier has control: a decision between taking the time to clear one' uniform versus leaving the tags in place in a kamikaze effort to accomplish the mission. This control, however, is somewhat tempered by the fact that soldiers would literally be working against the clock to save their lives. Clearly, both weapons represent a high degree of risk: for APLs, the risk is grisly injury; for tags, the risk is injury and death. Furthermore, the only real certainty about the two weapons is injury or death. Finally, making the tags hard to detect increases uncertainty.

Tags, like APLs, have the potential to affect both tagged and untagged soldiers. APLs obviously affect soldiers who encounter them by causing injury or death. APL injuries, however, also affect other soldiers in terms of morale, time, and aspects required for rescue efforts. For tags, removability impacts the control that untagged soldiers have in terms of helping their tagged comrades. By manipulating the ability to help comrades, tags also pose a threat to morale for units that have repeated experience with them.

So do the potential psychological and behavioral effects of tags mimic those of APLs? It appears that tags pose different but potentially equally powerful effects compared to those of APLs.

Potential Operational Effects

Kolasinski (1999) posed that an alternative to the exact replication of some or all of the psychological effects of APLs is replication of specific operational effects of APLs with or without the psychological ones. Thus, it is instructive to discuss the potential operational effects of tags.

As discussed in this report, tags appear to pose two major operational effects. First, tags have the potential to cause the enemy confusion during the period when they are trying to determine the nature of the Tags/MGM system. This, however, is not their major strength. Their major strength is the threat they pose to the attention and action of enemy soldiers. Initially tags may mentally distract the enemy as they try to figure out what the tags are and what they do. Once they understand the system, tags will likely divert enemy attention as soldiers decide whether or not to try to remove it. This may lead to efforts to try to remove the tag. Finally, some tagged soldiers may be fearful or anxious about their impending injury or death and be rendered unable to perform at all. All of these situations, of course, divert enemy attention from accomplishing the mission. Thus, referring back to the Tag Behavioral Effects Model, it would appear that tags offer an important operational effect of time. Whether it is time spent trying to determine how location is being revealed, time spent trying to decide whether or not to clear one's uniform, or time spent clearing one's uniform – it is all time focused on something other than accomplishing the mission and the task at hand.

Vinson (1998) identified three distinct functional features of landmines which, he asserted, any alternative must replicate in order to be an effective replacement. These

three features are activated simultaneously when a mine explodes. In such an instance, the mine serves in an alerting or observing capability, indicating the potential presence of hostile forces in the area; it communicates this information, signaling to friendly troops the possible approach of the enemy; and, finally, it acts against or attacks this threat. The Tags/MGM system would appear to offer the same three features. The signal sent from the tag indicates the potential presence – as well as the location – of hostile forces and communicates this information back to friendly forces, whereas the MGM acts against the threat.

Overall, as with the potential psychological and behavioral effects of tags, it appears that tags pose different but potentially equally powerful operational effects compared to those of APLs.

Next Steps

As noted, this report has raised many more questions than it has answered. The next step is to try to answer some of these questions. Overall, the goal is to be able to predict the psychological, behavioral, and operational effects of tags. For the most part, the literature is sparse in terms of providing clear answers to the questions. However, this report offers many tangential insights, and the preponderance of the evidence strongly supports the idea that the Tags/MGM concept has the potential to cause significant psychological, behavioral, and operational effects and is, thus, worth pursuing.

In July 2000, a paper will be presented at the Annual Meeting of the Human Factors and Ergonomics Society in an effort to solicit input on APL alternative concepts from the human factors community at large. Although this strategy may result in the revelation of additional supporting literature, the biggest benefit may be identification of researchers who would be willing to test issues specifically relevant to the Tags/MGM concept. Testing, in fact, is the most logical next step. Research units of the Army Research Institute and the Army Research Laboratory are both logical prospects for conducting tests. The Joint Readiness Training Center at Fort Polk, Louisiana is the Army's center for light infantry and special operations training and testing. The National Training Center at Fort Irwin, California is the Army's center for armor/mechanized forces training and testing. Both locations are potential centers for testing to the Tags/MGM concept.

Kolasinski (1999) noted that the only recourse following a comprehensive ban on the use of APLs and the employment of alternatives may be a paradigm shift in U.S. military strategy and operation. The Tags/MGM concept may be an important contribution to the new paradigm. Enough information exists to suggest that Tags/MGM is a concept worth pursuing, but more information is needed to make a comprehensive assessment.

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